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ON SOME RESULTS OBTAINED BY THE ATROPHY
METHOD.

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IN the sequel we shall have occasion to relate observations made by various methods of research employed on the brain axis of man and lower animals. But as the more novel and striking of these were derived from a case of artificially induced brain atrophy, and the latter constitutes as it were the text of this article, of which the other results collaterally obtained may be regarded as commentaries, we shall proceed to describe the former in its general features, before discussing special problems in cerebral anatomy.

The animal selected for operation was a kitten, one of a litter of six, and if anything, the largest and healthiest of these. A cataract needle was rapidly passed through the middle altitude of the lateral aspect of the skull, behind the left mastoid crest, obliquely inwards and downwards, to the floor of the skull, and then after a quick lateral motion, withdrawn. The time occupied by the operation, was at most three seconds, and but a drop of blood was lost. At the time of the operation the animal was two days old and the eyes were closed. It immediately showed *manège* movements, which were towards the right side; it walked round and round in a circle with its head and tail approaching each other on that side. This circle did not exceed the length

of its body, and consequently, though continually moving—as it did at all times it was observed—it did not get further than a few inches from any given spot in which it might be placed. It being found that this imperative motion invariably defeated all attempts to obtain nourishment—for it circled past the mother's tit,—it was fed by hand, a task requiring considerable patience, and which was accomplished by one of the female members of the household. The date of the operation was June 22d, 1884. Four days later the eyes opened, that is a day later than those of the other kittens of the same litter. It was already then evident that it was not developing as well. The *manège* movements continued in undiminished intensity for two weeks ; then it was noted, that it occasionally made attempts to walk straight and would even in attempting to overcome the *manège* to the right, show a brief deviation to the left. At the age of one month it walked straight, as a rule ; the occasional deviations noted were to the left, it often tumbled over on this side. In judging this phenomenon, the defect of vision should be borne in mind. It at this age began to play with the other kittens, but did not possess one-third their range of motion, nor anything like the same degree of skill. It still had to be fed, the food being pushed into its mouth. The animal often assisted this procedure by pushing its mouth against the feeding receptacle so as to retain its hold on it.

When the eyes opened, they both were noticed to be abducted ; two weeks later the right appeared normal in direction, also showed normal pupillary reactions. To the end, the left eye remained strongly abducted and there was complete left iridoplegia and mydriasis.

Its gait was particularly deliberate and slow, as far as both hind extremities were concerned, and it wobbled from side to side as if paraparetic. In stepping out, it stretched its hind-legs overmuch. It is able to rest on its left forepaw, raising the right in play, but holds its head in a peculiar position, as if to look with the left (abducted) eye on the floor. It evidently has the use of this eye, at least with a part of its visual field.

Cutaneous impressions appeared to be correctly localized, as far as reflex acts enabled us to determine. Except in so far as it was invalidated by defective nutrition, its muscular clumsiness and defective fields of vision, it appeared to have no defect of intelligence. It was exceedingly good-natured and far from being lethargic at this time. Some of the incidents noted in its subsequent career, are herewith detailed.

August 29th. Tried to get on the cross-piece of a chair in vain for over a quarter of an hour. The mother then called her kittens round her on a sofa. The others jumped up immediately—but the operated one after repeated failures was assisted by the little boy who had it in charge. When there it played with its mother. The other kittens evidently recognized its helplessness, and refrained from the rougher play which they indulged in with each other. In its manœuvres the defective one was often non-plussed, particularly in jumping at its antagonist, when, it either fell short or struck to one side, but it repeated the attempt again and again, evidently enjoying the sport as much as the uninjured ones.

September 5th. The animal has become more dull. It has retained the hair it was born with, not changing the fur as the healthy ones have done. It measures not fully two-thirds their average length, and does not equal one third (!) their average weight. Its head appears of the normal size, a slight narrowing at the temporal region is noted. The boy who had it in charge alone was capable of provoking it to action, when I exhibited it to my class. This he accomplished by imitating a fighting cat, it then ran towards him, bounding along in a line to the left, and "over-reaching" in raising the hind-quarters; being further provoked by the boy's imitation of a mewling and spitting cat, it mewed and spit in return.

This kitten was killed exactly ninety days after the operation, having become gradually more and more indifferent and passive. On examining the calvarium, it was seen that the sagittal suture, corresponded to the sulcus, separating the ectal gyrus from its fellow on the right cerebral hemis-

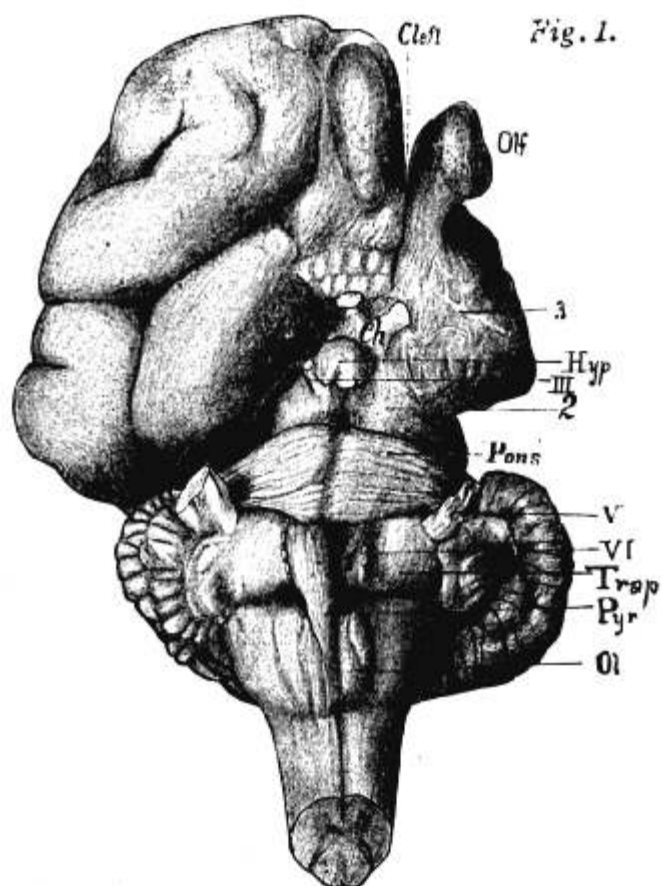
phere. In other words the right cerebral hemisphere protruded across the median line with a considerable portion of its mass.* On opening the skull cavity, it was found, that the right cerebral hemisphere occupied nearly the whole of it, there being but a shrunken membranous sac to represent its fellow, only the olfactory lobe as well as the adjoining region, in the anterior perforated space, exhibited something by which the normal elements could be identified.

There was no trace of any active morbid process anywhere. There was a glairy rust-colored material in the antero-inferior part of the cranial cavity, it was connected with a trabeculated membrane, which evidently represented the residue of atrophied cortex fused with the leptomeninges. Possibly there had been a hemorrhage, but no distinct traces of such were found. Behind the larger cyst representing the left cerebral hemisphere, were smaller ones, included in a common investment which at the base of the brain merged with the shrunken crus of that side. These cysts corresponded to the left thalamus, which, as far as its nervous tissue is concerned had been almost entirely eliminated. Nothing beyond a ridge like thickening of the cyst wall at the region of the habena gave the slightest indication of the normal components of the thalamencephalon. The left optic lobe † was shortened in the cephalo-caudal direction to one-half and in the transverse direction to two-thirds of its fellow ; it was very flat, while the right was beautifully prominent, and encroached to the extent of fully one-third of its own diameter, beyond the ideal plane of the axis. The dividing line between the optic lobes corresponded to the mesal margin of the right cerebral hemisphere.

There was no gross asymmetry of the cerebellum. At first, owing the distortion of the cerebral axis, it seemed as if the right lobe were slightly less voluminous than the left. The subsequent study by sections showed that this asym-

◦ The various measurements, made and recorded are omitted, except where they are of intrinsic interest.

† Anterior Pair of the Corpora Quadrigemina.



metry was apparent and not real in regard to bulk. What the right lobe lacked in width, it preponderated in, in regard to depth and fulness.

The distortion of the brain axis can be best pictured by a glance at the accompanying plate, (Figure 1). Beginning at the ethmoidal crest it ran obliquely caudad and to the right, in a rather direct line to the posterior border of the pons. Here it changed in direction sharply, the ventral furrow of the oblongata coinciding in direction with that of the cord. This asymmetry corresponded with that of the skull, the right half of which in front of the clivus greatly preponderated over the left, which was reduced in the three dimensions.

The optic nerves were both smaller than normal, the left was reduced to two-thirds the section-area of a corresponding healthy kitten, the right to about one-half, the latter was therefore the smaller.* There were no traces of the left optic tract; the right appeared normal. The hypophysis was symmetrical and normally developed in all its parts. The left oculo-motor nerve was entirely absent, the right entirely normal. The pons was as a whole smaller than in kittens of a corresponding age, but as subsequent examination showed equally so in all directions. The bulge in the right side of the basilar furrow was marked, in the left it was barely indicated. The left pyramid was entirely absent, and a depression marked the spot, where it is ordinarily located, the left olivary eminence consequently become entirely exposed, whereas the right was concealed in its cephalomesal part by the developed right pyramid. The distance between the left abducens radicles and the ventral-furrow was much less than that between the right abducens radicles and that furrow. A glance at the two figures (2 and 3) representing trans-sections respectively through the middle of the pons, and the trapezium shows the chief results produced by the elimination of the left thalamus and left cerebral hemisphere. The corresponding pyramid tract is

* The Figure does not show this, owing to the different direction of the dividing sections. The measurements were made near the entrance of the nerves in the eye ball.

entirely eliminated, not a trace of it can be discovered. The mesal division of the lemniscus (cortex-lemniscus of von Monakew, interolivary layer of Flechsig) is represented by atrophic relics.

The same is to be said of that intermediate division which is located between the mesal and lateral divisions : (Figure 2, L^1 on the right side, L^2 on the left side). The lateral division of the lemniscus is unaffected. The brachium conjunctivum (tegmenta-brachium, processus e cerebelli ad cerebrum) as well as the pontis-brachium also appears to be unaffected, or at least symmetrically developed. The posterior longitudinal fasciculus is much reduced on the left, as compared with the right side, while the tegmentum generally appears smaller on the left. A remarkable exception is noted in the field of large fibres situated near the raphe. These show a crossed atrophy, and our curiosity is aroused, and leads us to search for a relationship between them and the fibres of the fountain decussation of Meynert, or perhaps of the posterior commissure. The further caudad we proceed, the less markedly do these various asymmetries influence the contour of the trans-sections, and the deeper topography of the brain axis.

To sum up, the experiment had consisted in the nicking of the left lateral aspect of the mesencephalon, dividing the various tracts which run to the higher centres, in a direction ventro-mesad, the left optic tract, and the left oculo-motor nerve. All other cranial nerves, as well as the larger blood-vessels escaped. There then resulted a passive atrophy of all the centres and tracts directly represented in the destroyed area. The nuclei of the left oculo-motor nerve, the left thalamus, the left cerebral hemisphere and all tracts directly depending on the latter two, were eliminated so completely, that not a trace of their nervous elements could be discovered. To derive useful results from the observation of so extensive an atrophy, it will be necessary to take up tract by tract as influenced by the operation, and compare it with its condition in experiments where less severe mutilation had been accomplished. As we shall find, the *plus* of tract atrophy found in our case, as compared with v. Mona-

Fig. 2.

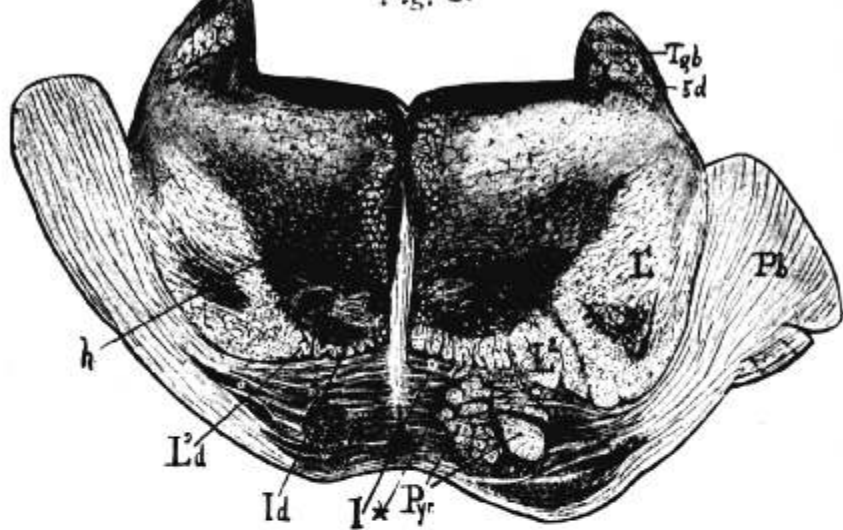
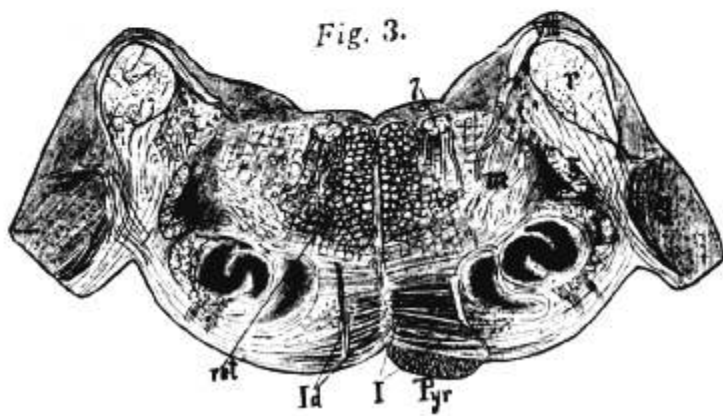


Fig. 3.



low and Forel's observations, is attributable to the destruction of the thalamus, and consequently we are enabled to determine the extent and course of certain of the tegmental fibre-systems.

(To be continued.)

FIGURE 1. Ventral view of the entire brain. *Cleft*: Median longitudinal fissure separating the two cerebral hemispheres; *Ol*, Left Olfactory bulb. 3. Left atrophic cerebral hemisphere, the pointer is on one of the obliterated vessels; *Hyp* Pituitary body; *Ch* Chiasm III. Right Oculo-motor nerve, the left being absent. 2. Cyst occupying the place of the left Thalamus, the pointer ends at the spot where the cyst terminates and the rudimentary crus begins; *Pons* Pons Varolii V. Left Trigeminaus, as the nerve is frayed out, it appears smaller than its fellow, in reality, they were symmetrically developed. 1. Depression corresponding to the eliminated left Pyramid bordered ectad by the (VI) Abducens roots. *TraP* Trapezium Pyr. Right Pyramid; *Ol* Left Olive entirely uncovered.

FIGURE 2. Trans-section of Pons. *Ph*. Brachium Pontis (medipedunculus) I. Right inter-olivary layer. *Id*. Left ditto, atrophied; *Pyr*. Right Pyramid tract. *L*¹ *L*² various divisions of Right and normal lemniscus. *L*²*d*. Left atrophied representation of the middle division. *Tgb*. Tegmentabrachium (Bindearm or prepudunculus); *5d*. Descending radicle of Fifth Pair; *h* crossed tegmental field.

FIGURE 3. Trans-section of Trapezium VIII. Auditory radicle. *L* part of Lemniscus, accumulating ectad of trapezial iris (so-called superior olive) *ret* Reticular Field, *r* Restiform column; *5* Ascending Radicle of Fifth Pair, *m* fibres, which in more cephalic levels become the lateral division of the Lemniscus, designated *L*¹ in Figure 2; *7* germ facialis; *Pyr* Pyramid Tract of Right Side; *L*. Right interolivary field, extent indicated by pointers *Id* atrophic Left interolivary field.